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NEW FACTS REGARDING THE BIOLOGY  
OF THE  
MOUNTAIN PINE BEETLE IN WESTERN WHITE PINE

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# NEW FACTS REGARDING THE BIOLOGY OF THE MOUNTAIN PINE BEETLE IN WESTERN WHITE PINE

## INTRODUCTION

Due to the lack of complete information concerning the biology and habits of the mountain pine beetle (Dendroctonus monticolae Hopk.) inexplicable peculiarities of the insect's habits have constantly occurred to confuse the administrators of control projects. This dearth of essential knowledge also gave rise to difficulty in the training of spotters relative to the proper marking of trees for treatment. Therefore, a biological study of the insect was instituted with the object of securing information which would aid in the solution of these many difficult problems which continually arose in connection with control operations.

Mr. Donald DeLeon instituted this work during the summer of 1930 at Metaline Falls, Washington, Kaniksu National Forest, and the writer continued the project during the field season of 1931. The following is a report of the study during the 1931 season.

## PARENT ADULT EMERGENCE AND REATTACK

Emergence holes have been noted in trees which contained brood that was too immature for emergence, being only in the larval stage. Upon examination, it was found that these holes led from egg galleries, and this suggested the possibility of parent adult emergence, with subsequent attacks in a fresh host. It can readily be seen that if

parent adult beetles do emerge from trees after propagating one brood and reattack green trees to generate a second brood, the number of infested trees the following year will be approximately twice the number normally to be expected.

To definitely connect one group of emerging parent adults with a subsequent attack, a wire screen cage (Fig. 1) was built around the basal ten feet of a green white pine tree, and on June 14, 1931, white pine logs and slabs from an infested tree which had been attacked on June 2, 1931, were placed in the cage. The cage included a bark surface of 31.43 square feet on the green tree and the bark surface of the infested material placed in the cage amounted to 52.48 square feet. Attacks did not appear inside the cage until August 7, 1931, and these were not very numerous. However, as stated later in this paper, I believe the June attacks are made by the combined efforts of overwintering parent adults and overwintering callow adults. The June attack then would be the second brood for a number of these parent beetles and, as I am also of the opinion that they raise but two broods, a very heavy attack within the cage was not to be expected. Concurrent with the attacks within the enclosure, the tree was attacked above the cage, thus showing that what had occurred within the cage was not abnormal and had not been induced by the caging. When the foliage began to fade and it was certain that the tree was dying, the cage was transferred to a green tree. The old tree was then felled and the formerly caged portion transferred to the cage on the green tree in order to ascertain if these parent adults will emerge



and make a third attack. No further developments were noted when observations were last made on November 1, 1931. When the cage was removed from the first tree, the infested logs and slabs were examined so that a comparison might be had of the two broods raised by the same group of parent adults. However, the basal ten feet of the first tree is now in the cage on the new green tree and examination of this material will not be made until next spring so that no comparison of broods can be given at this time.

Later, On August 15, 1931, a similar experiment was conducted and infested material having a bark surface of 37.6 square feet was placed within the cage which enclosed 36.6 square feet of bark surface on the green tree. The infested material was obtained from a tree attacked on August 11, 1931. By September 5, 1931 a very heavy attack on the caged portion of the tree, as well as a heavy attack above the cage, had taken place. Examination of the infested logs within the cage was begun, but so many living parent adults were yet to be found in the material that the examination was left for the spring, at which time the cage will also be transferred and the experiment carried on as the preceding one.

From these data, it can be stated that parent adult mountain pine beetles emerge from the June and August attacked white pine trees and reattack living green trees. The study, however, is necessarily incomplete and two features are yet doubtful; namely, emergence and reattack by parent adults from the July and September attacked trees, and whether or not the beetles will generate a third brood. More experiments

will be conducted next year to settle these dubious points by caging material from trees attacked during July and September on green trees.

#### PROPORTION OF SEXES

From time to time investigators have recorded an unequal proportion of male and female beetles in the galleries of newly attacked trees and these records brought up the question of the numerical inequality of sexes and its importance in the increase of the insect. It can readily be seen that if each brood contains more females than males, the infestation will increase beyond that normally expected in direct proportion to the number of extra females. Therefore, a study of the proportion of sexes was begun in connection with the other mountain pine beetle investigations.

The first step in this study was to determine the ratio of male and female beetles to be found in newly attacked trees. Daily observations were made of a restricted area, and when attacks occurred in early August, two trees were selected and the date of attack recorded. These trees were felled and examinations made on all sides at varying heights along the bole. Each gallery was opened carefully from the entrance hole to the end of the gallery and the sexes of all beetles found were determined. As the examination of all these beetles by the dissection of the genitalia under the microscope would entail the expenditure of too much time, and as no field characters for the separation of sexes were known, a method was devised to facilitate the work, whereby each individual insect was squeezed between the thumb and forefinger carefully so that all pressure within the beetle

resulted on the posterior portion of the abdomen. Thus the reproductive organs were forced out as a long slender filament from the male, and roughly in the form of a cross in the case of the female. Sex determinations of this sort were checked under the microscope with 100 beetles and found to be accurate.

Examinations of the same two trees were made at different times as the attacks progressed in age, with the exception, however, of the first three day old attack, which was examined early in the season. Height and exposure show no effect on the sex proportion and have been omitted in recording the data in Table I.

TABLE I

Trees : No. :	Date : of :	Age of : Attack :	No. of Galleries Containing : One : Female :	Male and : Female :	One Male & : Two Females :	Total : Males :	Total : Females :	Percent : Males :	Percent : Females :	Sex Ratio
0	6-5-31	3	33	54	6	60	99	37.7	62.3	1:1.6 or 5:8
1	8-14-31	4	68	118	0	118	186	38.8	61.2	1:1.5 or 2:3
1	8-18-31	8	17	39	0	39	56	41.0	59.0	1:1.4 or 5:7
2	8-18-31	7	42	112	0	112	154	42.0	58.0	1:1.4 or 5:7
1	8-24-31	14	21	54	0	54	75	41.8	58.2	1:1.4 or 5:7
2	8-24-31	13	50	75	0	75	125	37.5	62.5	1:1.4 or 5:7
2	9-3-31	23	71	129	0	129	200	39.2	60.8	1:1.5 or 2:3
Total			302	581	6	587	895	39.6	60.4	1:1.5 or 2:3



It will be noted that six galleries were found to contain three beetles. In all such cases, two beetles, a male and female, were found at the end of the gallery, and the third, a female, merely using the entrance hole for the beginning of her own gallery.

From Table I, it can be seen that the variation in the proportion of sexes due to the age of attack is so very slight that it can be considered as three females to every two males for the season of 1931.

To determine whether or not this ratio would be applicable to the beetles as they emerge from the old brood trees, prior to the attack on the fresh host, slabs of white pine wood, still retaining the bark, from which Dendroctonus monticolae brood was about to emerge, were placed in a large galvanized can. This can was especially constructed with a bottom sloping toward the center and in the center a hole, so that all emerging insects would fall below into a glass container. The container was emptied each day and the sex of each mountain pine beetle determined by dissection under the microscope. When emergence was complete, it was found that of the 107 beetles 50.4 per cent were males, and 49.6 per cent females, thus making a proportion of one male to one female.

To substantiate this finding, 893 callow adult beetles were collected at random, at different times, from different trees, and were dissected under the microscope to determine the sex. Including the can emergence, one thousand beetles were so examined, and of these 497



(49.7 per cent) were males and 503 (50.3 per cent) were females\*.

Thus there is an equal number of males and females when the young adults emerge from the trees and therefore, an unequal sex proportion does not enter as a factor which causes an increase of Dendroctonus monticolae beyond that normally expected.

Exactly what happens to the males between the time of emergence and attack, so as to cause the numerical inequality of sexes found in newly attacked trees, is difficult to say. I am inclined to state that they are eaten by predators. Clerids especially were very abundant in the region, and as the male beetles, following the females into the galleries, are exposed for a much longer time, it seems logical that more males than females would fall prey to the predators. Another possibility is that after fertilizing one female, the male may wander off in search of a new mate and in the course of his wanderings may die due to a number of agencies other than predators.

Concerning the proportion of sexes, additional study will be made of trees attacked in June, July and September and an attempt will be made to ascertain the exact fate of the males.

\* A similar study of 1015 Douglas fir beetles, showed 501 (49.3 per cent) males, and 514 (50.7 per cent) females for the emerging brood.

## PARTHENOGENESIS AND MATING HABITS

This excess of females in the newly attacked trees naturally created the question as to how they became fertilized, because Dendroctonus monticolae has always been considered a monogamic species. Only three theories were advanced to answer this question: first, fertilization took place before the beetles left the old brood tree; second, the females had parthenogenetic ability which they could use at will; and third, some males fertilized more than one female. The theory of parthenogenesis will be considered first.

Ten large mountain pine beetle pupae were placed in separate rearing jars and kept in as near natural conditions as possible until the resulting adult beetles were fully mature. Thus, being certain that these beetles were unfertilized, a fresh block of white pine was inserted in each of the ten jars and allowed to remain there for five weeks. Upon examination it was found that only four beetles had attacked the blocks. Of these four, two had died at the entrance hole, and the other two had constructed short irregular galleries of two and three inches respectively, but had laid no eggs. All four beetles were examined and found to be females. A check of this experiment existed in the form of successfully developing brood in similar blocks, used for parasite studies. This brood had been obtained by introducing males and females into jars and rearing the brood from the eggs, thus showing that had the unfertilized females laid fertile eggs, the rearing device would not have hindered the development of these eggs.

In addition, nine mature Dendroctonus monticolae adults were taken from individual pupal cells and each one was placed separately on a newly attacked white pine tree with a small piece of screen tacked over it to keep it isolated from all other beetles. Examination was made at the end of four weeks and it was found that six beetles made no attack, three constructed short irregular galleries but laid no eggs, and upon examination, these three beetles proved to be females. In another experiment, seven mature females (later examination under the microscope proved them to be females) were collected from individual pupal cells and started in small holes drilled in the bark of a newly attacked white pine tree. Each attack thus started was covered with a small piece of screen. Examination at the end of three weeks showed that all had constructed galleries from one half to eight inches, with the majority one inch in length. The galleries were twisted and had many side branches but contained no eggs. In both cases of screen experiments, successfully developing brood was present in the same tree all around the screened galleries.

Table II shows the results of these experiments.

TABLE II

Group	Type Experiment	No. of Beetles	Attack	Inches of Gallery	No. of Eggs
I	Rearing jars and white pine blocks	6	No		
		2	Yes	0	0
		1	Yes	2	0
		1	Yes	3	0
II	Screened in tree	6	No		
		2	Yes	3	0
		1	Yes	1	0
III	Screened on tree in artificial entrance hole	4	Yes	1	0
		1	Yes	5	0
		1	Yes	3	0
		1	Yes	8	0

These data show the absence of parthenogenesis in the case of Dendrectonus monticolae.

To determine whether mating takes place before the beetles leave the old tree or is perpetrated after arrival on the new host, two large green sections of white pine were placed in separate cages, each cage containing an infested section of pine from which new adults were about to emerge. When attacks had started in cage No. 1, all beetles not yet attacking were removed from the cage, thus hoping to eliminate all males. In cage No. 2, all beetles were allowed to remain.

Upon examination of cage No. 1, it was found that one male had accidentally been left, and he was discovered with a female in a gallery which contained eggs and larvae. The five other attacks present in this cage, each one containing a single female, had no eggs, and the galleries were the short irregular ones typical of the unfertilized females in the parthenogenesis study.



Examination of the section in cage No. 2 showed ten attacks. Four galleries, each one containing a male and female beetle, were possessed of larvae and eggs. Also, one gallery with but a single female in it contained eggs and larvae. The five remaining galleries, containing single females and no eggs, were characteristic unfertilized female galleries.

These data indicate that mating takes place after the beetles reach the newly attacked tree, and in the newly constructed gallery. Some males become polygamous in that after having fertilized one female, they emerge and seek another mate, while others remain monogamous. Just what causes some males to wander off and become polygamic is not known.

To substantiate these conclusions, four galleries from three quarters to one inch in length were observed in newly attacked trees, and each of these galleries contained a pair of beetles in the act of copulation. Furthermore, on two separate occasions, males covered with hardened pitch were noted following new clean females into galleries, thus indicating a second mating.

#### REVISED SEASONAL HISTORY

In the light of recent findings which augment former knowledge as to the seasonal history of Dendroctonus monticolae in western white pine, it seems advisable at this time to write a short revised seasonal history of the beetle as an addendum to this report. Although not yet complete, it will serve to bring our present knowledge up to date and thus, it is hoped, prove an aid in the administration of control projects.

The first attacks begin early in June, and continue to the middle of the month. Just what is the source of the beetles making this early infestation is not known. However, in the white pine region of northern Idaho and eastern Washington, three distinct brood stages are to be found in the spring of the year; namely, a few trees containing very small larvae, a slightly larger number containing only callow adult beetles, while the third and by far the largest number contains almost mature larvae. It is my belief that these first attacks are made by overwintering parent adults from the first group of trees, i.e., those containing the very small larvae, and overwintering callow adults from the third group; however, nothing definite can be said, and further study of this will be made next spring by caging the two classes of material in separate cages on green trees. The brood from these June attacks develops normally and is mostly in the callow adult stage by November 1st. This, then, is the brood which is found as callow adults in the spring. Though the time of emergence is not definitely known, it is believed that they emerge in June to aid in the making of the early group of newly infested trees.

The main emergence begins early in July and continues throughout September, but the greatest amount takes place during late July and early August. All broods which appear before the middle of August develop rapidly and are more or less mature larvae at the close of the season, overwinter in this stage, and emerge in July and early August of the following year. The late broods, occurring from the middle of August to

the end of the season, develop more slowly, overwinter as small larvae and emerge in late August and early September of the following year.

Parent adult emergence from the June attacks takes place in late July and early August, but is very slight, and as it occurs during the rain period of attack it blends completely with it and the brood development can be considered identical.

Parent adult emergence from trees infested during the main period of attack takes place approximately three weeks after the parent beetles enter the trees, although it varies from two weeks to five weeks, and the reattack occurs immediately after emergence. Brood development in these second attacks can be grouped with the others, depending on when the trees are infested.

However, it is my belief that new adults attacking late in the season; i.e., late September, do not have sufficient time to emerge, enter fresh trees, and propagate a second brood, and that these individuals therefore overwinter to emerge and make their second attack in the spring. It is also my opinion that Dendroctonus monticolae parent adults give rise to but two broods per season and die after generating the second brood. However, additional study is to be made next year, and it is hoped that these doubtful points will be solved.

#### SUMMARY

Entomologists on insect control projects found a need for more complete information concerning the biology and habits of the mountain pine beetle.

By caging infested sections of white pine at the bases of green trees, it was found that parent adults emerge from trees attacked in June

and August and reattack green trees.

The importance of sex ratio was studied by making sex counts in both newly attacked trees and trees from which the new brood was about to emerge. These showed a ratio of three females to every two males in newly attacked trees and a 1:1 ratio for the emerging brood. Hence, with Dendroctonus monticolae, sex ratio does not account for undue increases in broods. Predators are suspected as the agent causing the greatest loss of males between time of emergence and time of attack.

Parthenogenesis was tested as a means of reproduction for the excess females, by isolating female beetles and inducing them to attack. It was found that parthenogenesis is absent in the case of Dendroctonus monticolae.

In a study of mating habits, two groups of Dendroctonus monticolae beetles were colonized in separate cages. When attacks had started, the males were removed from one cage and allowed to remain in the other. Mating takes place in the newly constructed gallery after attack has started. These findings are substantiated by observations in the field.

Respectfully submitted,

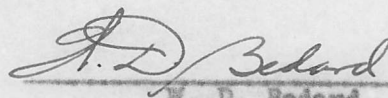
  
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Fig. 1 - The type of cage used for the  
parent adult emergence studies  
in White Pine.